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Norwegian Creek Dam, Harrison, Montana, Madison County, MT-1271

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

NORWEGIAN CREEK DAM
HARRISON, MONTANA
MADISON COUNTY
MT-1271

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

NORWEGIAN WATER USERS ASSOCIATION
(OWNER AND OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

APRIL 1980

SEATTLE DISTRICT
UNITED STATES ARMY CORPS OF ENGINEERS

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation, the U.S. Soil Conservation Service, the U.S. Farmers Home Administration, and the Norwegian Water Users Association, CH2M HILL inspected Norwegian Creek Dam on May 21, 1979, under the authority of Public Law 92-367. The dam is located on Norwegian Creek in Madison County about 6 miles south of Harrison, and 6 miles northwest of Norris, Montana.

This report was compiled from information obtained during an onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Norwegian Creek Dam, owned by the Norwegian Water Users Association, is used for irrigation water storage.

The 74-foot-high earth dam impounds 1,910 acre-feet of water at top of dam, elevation 5302 feet National Geodetic Vertical Datum (NGVD). On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. The dam is located such that its failure would potentially damage a state highway. It could also result in a sudden, unexpected increase in flow release over the spillway of a dam (Willow Creek) located 5.8 miles downstream from Norwegian Creek Dam. Therefore, the Norwegian Creek Dam is classified as having a significant (Category 2) downstream hazard potential. Inspection criteria (Ref. 1) recommend that the spillway design flood (SDF) for an intermediate-sized project, with a significant downstream hazard potential, be from one-half to the full probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that is reasonably possible in the region. Based on our assessment of downstream risk, we recommend this project be capable of safely handling one-half the PMF.

An estimated PMF was developed for the 12.9-square-mile drainage basin. Refinement of this estimate may either increase or decrease the final flood characteristics. The estimated PMF resulting from the 72-hour general storm has a volume of 13,200 acre-feet and a peak flow of 54,000 c.f.s.

Routing of the estimated PMF was started with the reservoir at spillway crest, elevation 5295.8 feet NGVD.

The routing of the general storm PMF indicates that the dam is overtopped during the PMF, when 12 percent of the total flood volume enters the reservoir. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such a failure would increase the potential for property damage downstream from the dam over that existing prior to failure. On the basis of the field inspection and preliminary hydrologic and operational analyses, Norwegian Creek Dam does not now conform to inspection guidelines with respect to discharge and/or storage capacities to safely handle the recommended spillway design flood (one-half the PMF). This project's spillway is considered inadequate. Because there is not adequate information on material characteristics, construction procedures, or water levels in the dam embankment, evaluation of embankment stability is not possible.

RECOMMENDATIONS

Immediately develop, implement, and periodically test a downstream warning plan for use in the event of possible dam overtopping or structural failure. Since the PMF used for the dam safety analysis is preliminary and not suitable for design, detailed hydrologic and engineering studies are needed to determine the downstream hazard and required spillway capacity, and the project modified as these studies indicate. Install piezometers, obtain samples, conduct laboratory tests, perform stability analysis, and modify embankment as required. If future development occurs in the area between Norwegian Creek and Willow Creek Dams, the hazard classification of Norwegian Creek Dam must be reevaluated based on downstream development existing at that time.

RICHARD L.
FOSTER
2646 E

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal I.D. No.	MT-1271
Owner	Norwegian Water Users Association
Operator	Norwegian Water Users Association
Purpose	Irrigation
Location	Section 36, T2S, R2W, Principal Meridian, Madison County, Montana
Watershed	Norwegian Gulch, a Willow Creek Tributary
USGS Quadrangle	Harrison
Downstream Hazard	Category 2 (significant)

2. RESERVOIR

Elevation at Normal Pool	5295.8 feet NGVD
Surface Area at Normal Pool	65 acres
Drainage Area	12.9 square miles
Normal Storage (Spillway Crest Elevation 5295.8 feet NGVD)	1,510 acre-feet
Maximum Storage (Dam Crest Elevation 5302.0 feet NGVD)	1,910 acre-feet
Surcharge Storage	400 acre-feet

3. SPILLWAY

Location	Left abutment
Type	Uncontrolled, unlined, trapezoidal channel

Width	Varies; 25 feet at control section
Length	525 feet
Crest Elevation	5295.8 feet NGVD
Capacity at Dam Crest	1,200 c.f.s.

4. OUTLET WORKS

Discharge Conduit	24-inch-diameter reinforced concrete, partially concrete encased
Length	340 feet
Gate	At Dam center, 24-inch-diameter slide gate at wet well
Capacity at Dam Crest	75 c.f.s.

5. DAM

Type	Homogeneous earthfill
Length	650 feet
Crest Width	20 feet
Crest Elevation	5302.0 feet NGVD
Hydraulic Height (Crest to Toe)	74 feet
Upstream Slope	1 V on 3 H
Downstream Slope	1 V on 2 H

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Norwegian Creek Dam, owned by the Norwegian Water Users Association.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations, and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

The guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) A limited investigation to assess the general safety condition of the dam.
(2) Based upon an evaluation of the available data and a visual inspection.
(3) Performed to determine whether any needed emergency measures and/or additional studies, investigations, and analyses are necessary or warranted.
(4) Not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The details of Phase I recommendations must be developed in the Phase II investigation. It includes all additional studies necessary to evaluate the safety of the dam and to develop the detailed correction recommendations. Included

in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulics and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations, except for situations of extreme emergency. In these cases the Corps may proceed with Phase II studies, but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The Corps has no authority to enforce the recommendations contained in the safety reports. The responsibility for implementing the Phase I recommendations or initiating the Phase II studies rests with the dam owner and the State of Montana. Before any action to implement report recommendations, the owner is urged to contact the Montana Department of Natural Resources and Conservation. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project, a detailed review of available plans, specifications, and design analyses. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the May 21, 1979, inspection included:

Tom Ferguson, State of Montana Department of Natural Resources and Conservation
Larry Tegg, State of Montana Department of Natural Resources and Conservation
Mrs. Sitz, Norwegian Water Users Association

Bob Rice, Norwegian Water Users Association
Don McAndrews, Area Conservationist, Soil Conservation Service
Mick Sweeney, Engineer, Soil Conservation Service
Eldwin Sorensen, Assistant County Supervisor, Farmers Home Administration
Richard D. Eckerlin, Geologist, Corps of Engineers

CH2M HILL personnel who participated in the field inspection and contributed to this report are:

Miles C. Bubenik, Geotechnical Engineer, Team Leader
Loren Bottorff, Hydrologist/Hydraulics Engineer
Jerry L. Jacksha, Geotechnical Engineer

This report has been reviewed by the following, and their comments are attached in the Appendix.

Rice Ranches
Montana DNRC
U.S.D.A. Soil Conservation Services

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Norwegian Creek Dam is an earth embankment located on Norwegian Creek, a tributary of Willow Creek, in Madison County, Montana, about 6 miles south of Harrison (Plate 1). The Federal dam identification number is MT-1271, and it is currently listed in the national dam inventory as having a high downstream hazard potential (Category 1). The inventory will be changed to reflect conditions found during this inspection.

The 74-foot-high, 650-foot-long dam forms a 65-acre lake that has 1,900 acre-feet of storage at dam crest, elevation 5302 feet NGVD, and is used primarily for irrigation by the Norwegian Water Users Association. Based on a visual reconnaissance and engineering judgment, a state highway could be affected by a sudden breach of the dam. Failure could also cause a sudden unexpected flow release over the spillway of the downstream Willow Creek Dam.

An unlined chute spillway is located on the left abutment (Plate 2). The low-level outlet, used to regulate irrigation water releases, is a 24-inch-diameter reinforced concrete conduit through the embankment and a single 24-inch-diameter gate valve.

1.2.2 Regional Geology and Seismicity

The geology and seismicity of the Norwegian Creek reservoir area were addressed in a memorandum by R. D. Eckerlin (Ref. 5). The following information is taken from that memorandum.

Norwegian Dam is located on Norwegian Creek, which is situated on the eastern flank of the Tobacco Root Mountains within the northern Rocky Mountains physiographic province. These rugged mountains are composed mostly of Precambrian igneous and metamorphic rocks that have been dissected by stream erosion and modified by alpine glaciation.

The dam lies in an area that is seismically active; it is estimated that the dam experienced a 0.2 g bedrock acceleration during the 1959 Hebgen Lake earthquake. The Inspection Guidelines (Ref. 1) Seismic Zone Map shows the site in Zone 3, which has a potential for major earthquake damage. Although the Zone Map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site.

1.2.3 Site Geology

The discussion of site geology is also taken from the R.D. Eckerlin memorandum (Ref. 5).

Norwegian Dam spans the inlet of a gorge cut into bedrock. The dam is presumed to be founded on bedrock and locally on stream alluvium. Dam construction contract specifications state "foundation and abutments shall be excavated to a reasonably smooth surface free from loose chunks of soil or rock. . . ." This statement implies that excavation was not carried entirely to bedrock across the base of the dam.

Both abutments are founded on gneiss bedrock. Bedrock downstream and on the slopes above the crest of the dam has been rounded and smoothed by stream erosion. Gneiss exposed at the dam crest on the right (south) abutment contains widely spaced joints on the order of 1 to 5 feet, while at the left (north) abutment, jointing is frequent and generally less than 2-foot spacings. The left abutment gneiss reflects the type of rock that would be expected on the outer edge of such an intrusion as the Tobacco Root Batholith. Numerous acidic and basic dikes cross-cut the banded granitic gneiss with foliations striking N20W at 55° east dip. Most joints in the rock strike northeast and dip 45° to 70° south. Locally, slopewash conceals the bedrock.

The spillway consists of an unlined chute channel blasted through the left rock abutment. The rock consists of granitic

gneiss with foliations striking N20W and dipping 55E at the inlet, and striking N50W and dipping 70E at the downstream spillway falls. Most joints strike northeast and dip 45° to 75° south.

The 24-inch-diameter outlet pipe is shown founded on bedrock. At the discharge end of the outlet pipe, bedrock is exposed on the left side in a highly fractured, near-vertical face rising about 10 feet above the invert. In this area, rock could easily become dislodged with successive freeze-thaw cycles and fall over the outlet.

Much of the bedrock surrounding the reservoir is covered with Quaternary deposits of various kinds (including glacial, alluvial, slopewash, and lakebed). Both Canadian and Norwegian Creeks flow into the reservoir. A reconnaissance of the reservoir was not made; however, the nature of the silts, sands, and gravels in the area, coupled with the gentle slopes along the reservoir shoreline, suggests that landsliding is not a problem. The shoreline is relatively free of trees.

1.2.4 Design and Construction History

The Norwegian Creek project was designed in 1958 by E. H. Sperry, State Conservation Engineer for the U.S. Soil Conservation Service. Funds for the project were provided by the Farmers Home Administration. Construction was completed in 1958, and the as-built drawings and construction specifications are on file with the State of Montana. Results of material tests on borrow samples conducted in May 1958 (prior to construction) by the U.S. Soil Conservation Service (SCS), Lincoln, Nebraska, Soil Mechanics Laboratory, were available for review. No construction control tests or written accounts of actual construction were available.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Norwegian Creek Dam is located at the left abutment (Photos 1 and 2). The spillway consists of an uncontrolled and unlined channel. The left spillway slope and most of the channel bottom were excavated in rock. The right channel training dike is fill material from the excavation (Photo 3). Approximately 5 c.f.s. was flowing in the spillway at the time of the inspection.

The construction plans show the spillway channel as a trapezoidal section with 1 V on 1 H side slopes and a bottom width of 40 feet (Plate 3); however, a bottom width varying from 25 feet to 40 feet was measured in the field. The entrance to the spillway channel is partially blocked by a growth of young willows. The spillway channel control section is 25 feet wide and is located approximately 30 feet downstream of the entrance at a crest elevation of 5295.8 feet NGVD, which is 6.2 feet lower than the low point on the dam crest. Upstream from the control section, the channel invert has an adverse slope, while the spillway channel slope downstream from the control section is about 2 percent (Plate 4). Approximately 250 feet downstream of the crest the channel steepens. Soft seams of rock in the channel have been eroded, and the channel invert drops suddenly in places by as much as 8 feet. The channel ends as a cascade to the stream channel downstream of the dam. This discharge point is sufficiently removed from the dam and does not currently affect dam safety.

The unlined spillway channel is confined by an earth- and rock-filled training dike on the right side. The material is erodible and under sustained high spillway discharges, this dike may not be stable. Dike failure would result in erosion of the dam embankment, which would cause failure of the dam.

The discharge rating of the spillway was developed by calculating flow over a trapezoidal, broad-crested weir with a discharge coefficient of 2.65. Losses through the growth of willows at the channel entrance were not used since the willows can easily be removed. An energy loss of 0.3 of the velocity head was used to account for channel entrance

conditions. The maximum spillway discharge, with the reservoir at the crest of the dam, elevation 5302 feet NGVD, was estimated to be 1,200 c.f.s. The discharge rating curve is presented on Plate 5.

2.1.2 Outlet

The outlet works for Norwegian Creek Dam is located through the embankment about 300 feet from the left abutment (Plate 3). The intake structure could not be examined at the time of our inspection because of the high reservoir water surface level, but construction plans show it as a pair of converging wing walls covered by a trash rack. The concrete conduit is a 24-inch-diameter section approximately 340 feet long and founded on bedrock. A wet well gate tower is located approximately 172 feet downstream of the intake structure (Plates 6 and 7). The conduit has a slope of .0233 from the intake structure to the gate and .0204 from the gate tower to the outlet structure. The operating equipment for the 24-inch-diameter slide gate is located in a shack at the top of the gate tower and is in very good condition.

The outlet structure at the downstream toe of the dam was partially covered by slough material, and the structure almost submerged by tailwater. Some erosion has occurred on the left (looking downstream) side of the channel, just downstream of the outlet structure. This erosion does not endanger the dam. A turnout structure to a canal is located about 100 feet downstream from the outlet structure. Stoplogs can be placed across the channel to raise the water surface for entrance to the canal.

The outlet works was rated with the gate fully open. A Manning's "n" of 0.013 was used to estimate friction losses with the conduit flowing full. The maximum discharge capacity of the outlet works, with the reservoir at the top of the dam, elevation 5302 feet NGVD, was estimated to be 75 c.f.s.

2.1.3 Freeboard

Routings indicate that the dam overtops at 12 percent of the PMF volume; therefore, there is no freeboard with the recommended spillway design flood. The vertical distance to the dam crest from the reservoir water surface at the time of the inspection was approximately 5.9 feet, and the reservoir was about 0.3 feet above the spillway crest. The crest of the dam varies about 0.4 feet in elevation over its 650-foot length. The fetch for wind-generated waves is about 2,000 feet, and wave runup on the embankment is estimated to be about 3 feet. The operating freeboard for normal pool conditions is adequate to prevent overtopping by wind waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is continental in nature, characterized by warm summers and cold winters. The nearest climatological station (elevation 4700) is at Norris, about 7 miles southeast of the center of the basin. Mean annual precipitation at the station is 18.5 inches, with 52 percent falling in April through July. Mean February precipitation is 0.65 inches and mean July precipitation is 3.36 inches. Mean annual precipitation on the Norwegian Creek Dam drainage basin is probably near 14 inches. Mean annual temperature at Norris is 47 degrees Fahrenheit (F); mean January temperature is 25.9 degrees F and mean July temperature is 70.3. Temperatures on the Norwegian Creek Dam drainage basin probably average about 5 degrees cooler than Norris. Summer temperatures can exceed 100 degrees F, and winter temperatures can dip well below 0 degrees F. Winters have few extended cold spells, and periods of warm "chinook" winds occur between cold spells.

The drainage basin area for Norwegian Creek Dam is 12.9 square miles. Basin elevations vary from 5300 feet at the dam to 7950 on the southwestern boundary. The upper half of the basin is steep and forested, with stream gradients averaging about 560 feet per mile. The lower half of the basin is rolling rangeland, with stream gradients averaging about 150 feet per mile. Norwegian Creek and Canadian Creek are the two main inflow streams to Norwegian Creek Reservoir. Norwegian Creek, Rattlesnake Creek, and Preacher Creek join together approximately 1 mile upstream of the reservoir. There are no USGS stream gages in the basin or in surrounding basins.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 65 acres and storage of 1,510 acre-feet at spillway crest, elevation 5295.8 feet NGVD. Approximately 400 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The spillway discharge with the reservoir at the dam crest is 1,200 c.f.s., about 100 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir. The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. An

estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The procedure contained in the U.S. Weather Bureau's Technical Paper 38 (Ref. 2) was used to compute the probable maximum precipitation (PMP). This storm produces 11 inches in 6 hours and 15.2 inches in 24 hours. The 72-hour precipitation was estimated to be 17.5 inches, 115 percent of the 24-hour precipitation value.

Frozen ground and no infiltration losses were assumed during the entire flood. A base flow of 195 c.f.s. was used for the entire flood.

A triangular unit hydrograph for a 20-minute rainfall duration was developed for the 12.9-square-mile drainage basin by procedures outlined in Design of Small Dams (Ref. 3). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program HEC-1 (Ref. 4). This estimate of the PMP produced a flood with a peak of 54,000 c.f.s. and a volume of 13,200 acre-feet.

2.2.4 Flood Routing

The PMF was routed through the reservoir using the computer program HEC-1 (Ref. 4). The reservoir level was assumed to be at the spillway crest at the beginning of the PMF and the outlet gate was assumed to be fully open. The routing shows that the dam will be overtopped during the PMF when approximately 12 percent of the total flood volume enters the reservoir. This indicates that the dam could overtop and fail during floods much smaller than the PMF.

The storage volume of Norwegian Creek Reservoir at the point of dam overtopping is about 1,900 acre-feet. This volume, if released, would raise Willow Creek Reservoir by approximately 2 feet if Willow Creek Reservoir is near spillway crest.

Failure of Norwegian Creek Dam could cause overtopping of Willow Creek Dam; however, for such an occurrence Willow Creek Reservoir would have to be at an elevation approaching 2 feet of dam crest when Norwegian Creek Dam failed. This combination of events is considered to be improbable.

A rise in Willow Creek Reservoir's water surface, resulting from failure of Norwegian Creek Dam, would increase the head on the Willow Creek Dam spillway, thereby causing an abrupt increase in outflow from the Willow Creek Dam. The impact of such an increase in flow downstream from Willow Creek Dam

is variable, depending on the initial Willow Creek Reservoir elevation, but could potentially produce the following effects:

- With Willow Creek Reservoir at the spillway crest elevation, the increased downstream flow would likely be contained in the river channel with low potential for loss of life and/or property damage.
- With Willow Creek Reservoir at an elevation such that the downstream channel is near, but below flood stage, the increase in flow would cause sudden, unexpected overbank flooding, and could endanger life and/or property.
- With the Willow Creek Reservoir at an elevation such that the downstream area is already experiencing flooding conditions, the increase in flow from Willow Creek Dam could endanger persons involved in flood-fighting activities.

2.3 GEOTECHNICAL

2.3.1 Dam Embankment

The 74-foot-high earth dam has a crest width of 20 feet and a crest length of 650 feet. The upstream slope is 1 V on 3 H and the downstream slope is 1 V on 2 H.

As-built construction plans (Plate 7) show a homogeneous embankment section. A detailed description of the dam foundation preparation is not available; however, drawings show the dam foundation was stripped and the cutoff trench excavated to bedrock. It is not known whether the cutoff trench was excavated to bedrock in all areas. A section through the dam and a centerline profile are shown on Plate 7. It is not known whether the cutoff trench was excavated to bedrock in all areas.

The 24-inch-diameter, concrete, low-level outlet conduit is encased in concrete according to construction drawings (Plate 7). During an interview at the dam site with Mr. Sweeney, he stated that the foundation for the outlet tower and conduit was lowered about 10 feet below what was originally planned in order to place the control tower on rock. The conduit has several seepage cutoff collars under the downstream portion of the embankment.

Borrow materials for embankment construction were obtained from several sources in the reservoir.

Visual inspection indicated the surface embankment material was a mixture of sandy silt with some gravel. What was observed differs slightly with borrow material classifications stated in an SCS memorandum reporting on laboratory tests (Ref. 6). This memorandum classified one borrow material as silt-sand mixtures and another as sand-clay mixtures. There is no known boring information of borrow materials or construction data describing the actual embankment materials. Both the field inspection and the SCS laboratory tests indicate the embankment is constructed of fine-grained materials, which would quickly erode and rapidly fail if overtopped.

The downstream slope was sparsely covered with vegetation (Photo 4). A heavy growth of small willows covers the upstream slope (Photo 5). While the upstream slope has some riprap, minor erosion caused by wave action has occurred. No irregularities, slumps, or cracks were observed on the dam crest or downstream slope at the time of the inspection.

2.3.2 Foundation Conditions, Seepage, and Drainage

As-built construction drawings indicate that the original ground was stripped and a cutoff trench excavated, as previously described in Section 2.3.1. Specifications state that a foundation drain (6-inch-diameter corrugated metal pipe surrounded with well-graded, 1-inch minus gravel) was to be placed as shown on Plate 3. The 8-inch concrete drainpipe, shown in Photo 6, is connected to the foundation drain as shown on Plates 2, 3, and 7. The "as-built" table of contents suggests that the pipe drains are surrounded with sand and gravel filter materials. On May 21, 1979, the day of the inspection, with the pool at elevation 5296.1 feet NGVD, pipe discharge was about 20 gpm and flowing clear.

Seepage observed at the left abutment contact with the dam embankment, which originates from the spillway channel rather than the dam (Photo 7), was flowing clear, and the quantity was about 5 gpm. Erosion has not occurred because of riprap placed along the contact. Wet areas and standing, clear water were noticed at the downstream toe, near the embankment center. Snow was melting on the right abutment, so the surface water at the toe may have been from snowmelt. Wet areas at the downstream toe were also noted during an April 1977 Soil Conservation Service inspection (Ref. 6), described as follows:

> "There is a seep area at the toe of the back slope of the dam, as indicated by wetness, and the presence of water-loving plants, but a 6-inch perforated, corrugated metal pipe (CMP) drain carries this to an 8-inch perforated concrete drain outlet."

The right abutment contact was dry, but it showed some signs of past minor runoff.

There are no piezometers installed in the dam.

2.3.3 Stability

The earthfill embankment is constructed of fine-grained sandy silt and sandy clay that would quickly erode and rapidly fail if overtopped by floodwaters. The embankment has an internal drainpipe, which is described in Section 2.3.2; however, the effectiveness of the drain is unknown.

No stability analysis of the dam embankment is on file. Some strength and gradation tests on borrow materials are on file. The source of the materials used in the tests is unknown; therefore, the test results may or may not represent materials used in the embankment construction. Additionally, the laboratory triaxial test was not conducted on saturated samples and, therefore, the results are not representative of strength parameters required for the analysis of embankment stability.

Considering the lack of valid strength data, the apparent homogeneous embankment section, and the the unknown effectiveness of the internal drain, the embankment stability cannot be evaluated.

2.4 PROJECT OPERATIONS AND MAINTENANCE

The facility is owned and operated by the Norwegian Water Users Association.

2.4.1 Dam

The dam appeared to be well maintained. The downstream face of the dam was covered with grass and a light growth of sagebrush, but the upstream face was covered with a heavy growth of willows at the waterline. It is unknown how far down the face, beneath the water, the willows extend. The spillway channel has experienced some erosion, but it does not endanger the dam at this time. The U.S. Soil Conservation Service conducts periodic inspections of the facility, usually at 3-year intervals.

2.4.2 Reservoir

The reservoir is operated by the water users. Mr. Bob Sitz and Mr. Bob Rice operate the outlet works. The reservoir is usually filled in the spring and water is used as needed for irrigation. Diversions into the canal below the dam are

usually started by the middle of May, but this year the diversions were delayed because portions of the canal were blocked by snow.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines, performance standards, resulted in the following findings.

3.1.1 Size, Hazard Potential, and Safety Evaluation

The 74-foot-high Norwegian Creek Dam impounds 1,900 acre-feet of water with the reservoir at the crest of the dam. Before our on-site inspection, the national dam inventory listed Norwegian Creek Dam as having a high downstream hazard potential, presumably because of the belief that failure of Norwegian Creek Dam could induce failure of the downstream (5.8 miles), high-hazard Willow Creek Dam. However, the necessary combination of events that would cause Norwegian Creek Dam to fail Willow Creek Dam are considered too improbable and remote to designate Norwegian Creek Dam as high hazard, based on this premise. Therefore, in accordance with the inspection guidelines, the project is intermediate in size and has a significant (Category 2) downstream hazard potential. The recommended spillway design flood for this project is 50 percent of the PMF. Because the project can safely control only 12 percent of the PMF without overtopping and causing the dam to fail, the Norwegian Creek Dam is not in conformance with the inspection guidelines criteria.

3.1.2 Embankment Dam

A visual inspection of the dam revealed no longitudinal or transverse cracking, as well as no irregularities in section. The downstream slope has a scattered growth of brush. The upstream slope, partially covered by riprap and by a growth of small willows, has undergone minor erosion from wave action. The embankment is an earthfill, and the inspection team observed fill material to be a sandy silt with some gravel. Laboratory tests on borrow materials by SCS classified the materials as silty sand and sandy clay.

Ponded, clear water was observed at the downstream toe near the center of the dam and may be the result of snowmelt. Discharge from the internal drain was 20 gpm and the water was clear. Seepage from the spillway training dike was flowing down the left abutment. No significant erosion or

piping of soil materials was observed with the seepage, the standing water, or the flow from the embankment drain.

No stability analyses were available for review. Because piezometric information and adequate strength data are not available, the stability of Norwegian Creek Dam cannot be evaluated.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of 65 acres and a storage of 1,510 acre-feet at spillway crest, elevation 5295.8 feet NGVD. Approximately 400 acre-feet of surcharge storage are available in the reservoir between spillway crest and dam crest. The discharge of the spillway, with the reservoir at the dam crest, is 1,200 c.f.s. Portions of the spillway discharge channel were heavily eroded, and continued erosion will endanger the dam.

3.1.4 Outlet Works

The outlet works appeared in good condition, except for sloughing at the outlet structure. The conduit was not inspected because of its small size.

3.1.5 Operations and Maintenance

The facility is owned and operated by the Norwegian Water Users Association. There is no formal operations and maintenance program; however, the dam appeared to be well maintained.

3.2 RECOMMENDATIONS

The findings suggest that high priority be given the following recommendations:

1. Immediately develop, implement, and periodically test a downstream warning plan in coordination with the downstream warning plan for Willow Creek Dam, for use in the event of dam overtopping.

2. Remove all trees and brush from the upstream slope and spillway channel entrance. Backfill and compact all depressions.

3. Annually, inspect erosion along upstream embankment slope and repair damage as required.

4. Periodically monitor erosion in the spillway discharge channel and repair damage as necessary to protect the dam.

5. Inspect the low-level outlet conduit and repair, if required.

6. Remove slough material from the outlet conduit exit and the surrounding area. Modify exit as required to prevent continued sloughing of soil around conduit exit.

7. Re-inspect downstream toe to determine source of the standing clear water along the downstream toe.

8. Investigate the dam foundation, abutments, and embankment; conduct laboratory tests; install piezometers and establish water levels in the dam embankment; and conduct stability analysis. This study must be performed by a qualified and experienced geotechnical engineer. Modify the embankment as studies indicate in order to bring the stability into conformance with the recommended guidelines criteria.

9. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate. If future development occurs between Norwegian Creek and Willow Creek Dams, then the Norwegian Creek Dam downstream hazard potential and spillway capacity must be reevaluated based on downstream development existing at that time.

10. Conduct engineering studies to determine whether the spillway training dike is stable during all flows. Modify the training dike as required to safely convey all flows.

11. Conduct periodic inspection of Norwegian Creek Dam at intervals not to exceed 5 years, by engineers experienced in dam design and construction.

    Before performing engineering studies and remedial construction, coordinate the work with the State of Montana Department of Natural Resources and Conservation (Office of Dam Safety) to ensure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. U.S. Weather Bureau, Technical Paper 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Washington, D.C., 1960.

3. U.S. Bureau of Reclamation, "Design of Small Dams," 2nd Edition, 1974.

4. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.

5. Richard D. Eckerlin, U.S. Army Corps of Engineers geologist, Memorandum on Norwegian Creek Dam Inspection, June 7, 1979.

6. Ray S. Decker, Soil Conservation Service, Office Memorandum on Laboratory Tests, SCS Laboratory, Lincoln, Nebraska, May 19, 1958.

7. State of Montana, Support Data, Norwegian Creek Dam, "Inspection Memorandum by Soil Conservation Service," April 4, 1979.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR
32 SOUTH EWING
STATE OF MONTANA
(406) 449-2872
HELENA, MONTANA 59601

March 7, 1980

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

We have reviewed the final draft report on Norwegian Creek Dam (MT-1271). We concur with the findings and recommendations and feel that the report satisfies the criteria for Phase I evaluation. Minor comments have been discussed with your staff and we understand that they will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:mb

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P.O. Box 970
Bozeman, MT
59715

March 4, 1980

Sidney Knutson, P.E.
Asst. Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
PO Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

We appreciate the opportunity to review the final draft of the Phase I Inspection Report for the Norwegian Creek Dam Project, Harrison, Montana. Our case file has been purged over the years and the availability of information is limited. In discussions with some of the people who were on board at the time, they state the design was made in accordance with Soil Conservation Service criteria of the time. We do not have any comments to make on the report as presented.

Sincerely,

for Van K Haderlie
State Conservationist

cc:
Don McAndrew, Area Conservationist, SCS, Bozeman, MT

Rice Ranches
BOB RICE AND SONS
Box 201 Phone 685-3367
Harrison, Montana 59735

February 27, 1980

Department Of The Army
Seattle District, Corps Of Engineers
Sidney Knutson, P.E.
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson,
Please consider my comments on the Norwegian Creek Dam and the Bell Lake Dam.

Norwegian Creek : The railroad trestle which you consider as being in grave danger in case of flooding is owned by Rice Ranches, and is in the process of being dismantled. The railroad tracks had been removed before your men inspected the dam. The highway bridge in this area has a large opening and is located on very level ground. Very little water has ever ran over the dam spillway. The oldest people in our valley cannot ever remember flood conditions comparable with the proportions that this survey indicate. Most of the creek area below the dam is owned or leased by Rice Ranches. Over 4½ miles of Norwegian Creek below the reservoir is flat and brushy with swamp area which would retain much of the run-off if dam were ever to fail. I do not agree with this report.

Bell Lake: If this dam were to fail, very little of the water would leave, because of the manner that it is constructed with so many rock in the area. I do not agree that this dam would wash away fast as the report implies. There is very little floating debree in the area and what there is is small in size and would not hinder the spillway. There is so much solid rock in rip-rap below the dam, that it could not move as stated in report. I feel that if the dam broke, the discharge would be so slow that it could never endanger the camp ground, because of the speed of the creek at this spot would take care of an abundant supply of water. We do not agree that there would be a large run off or PMF in this area because of the small drainage area.

Sincerely,

Bob Rice

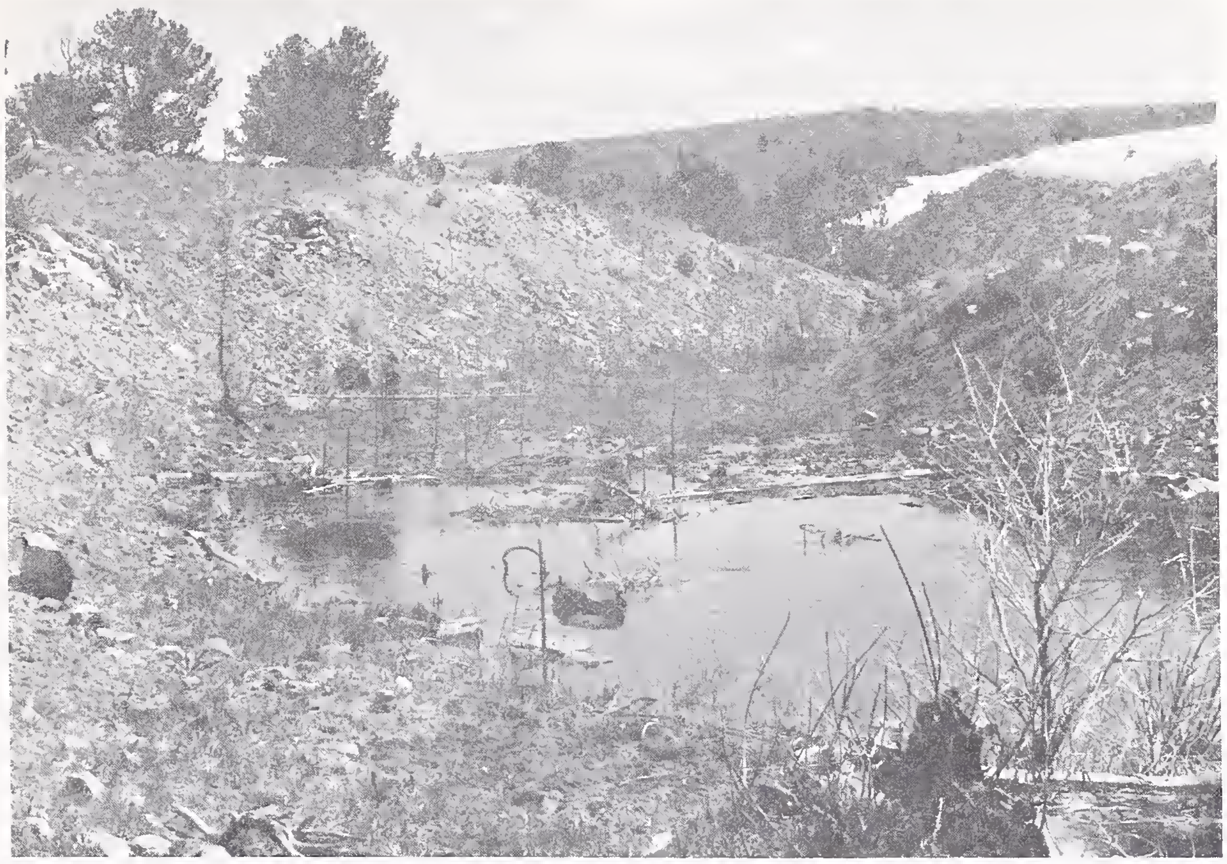


PHOTO 1 Spillway Discharge Channel Downstream From Crest

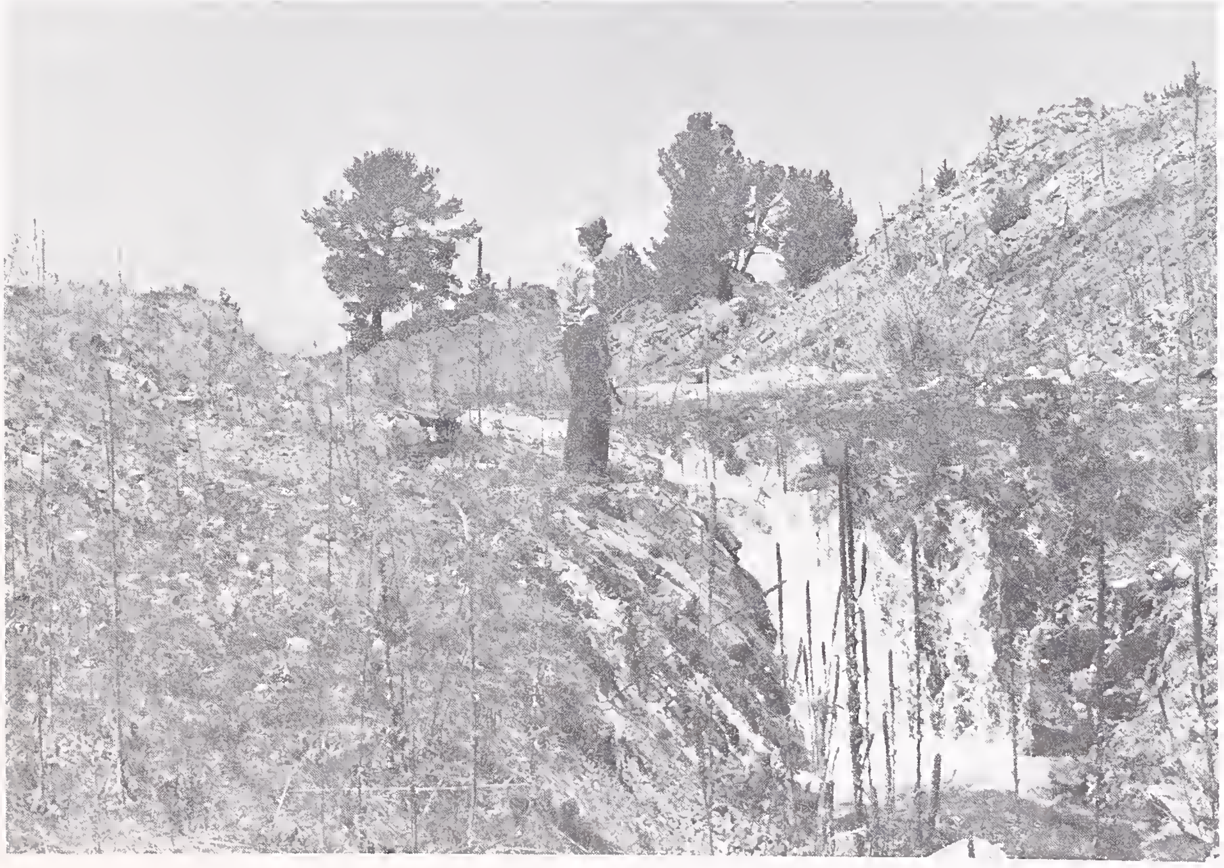


PHOTO 2 End of Spillway Discharge Channel

PHOTO 3 Spillway Training Dike on Right Side of Channel

PHOTO 4 Dam Embankment

PHOTO 5 Upstream Slope of Dam Embankment

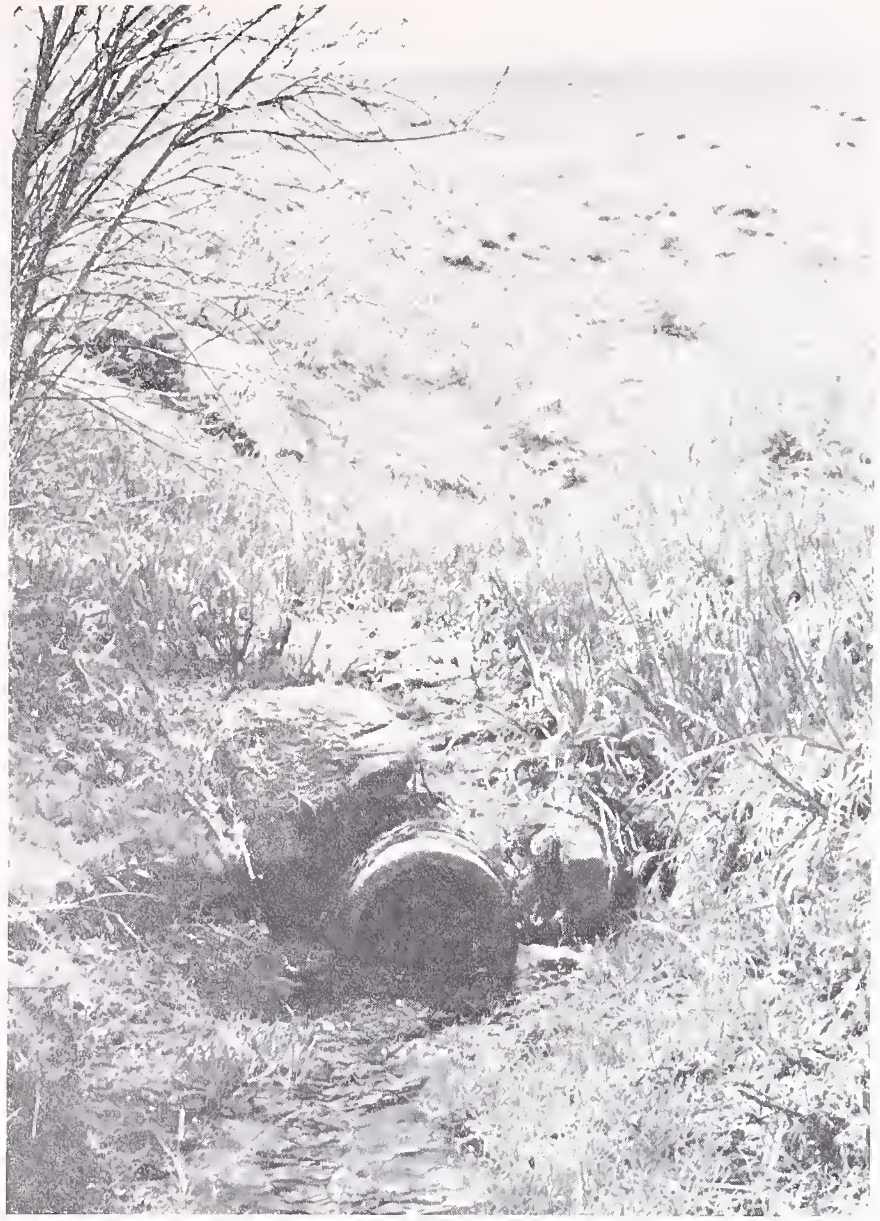


PHOTO 6 Embankment Drain Exit

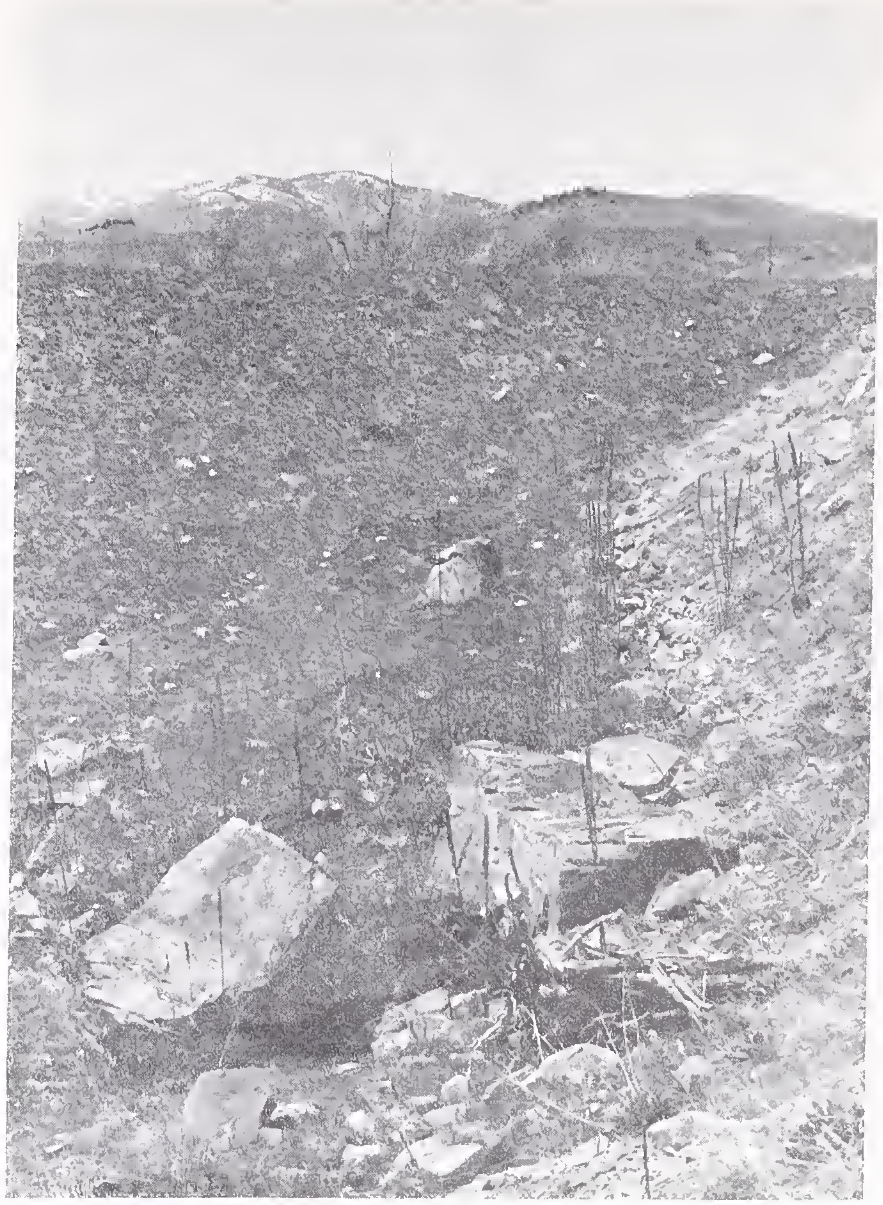


PHOTO 7 Seepage In Foreground at Spillway Channel Training Dike Toe

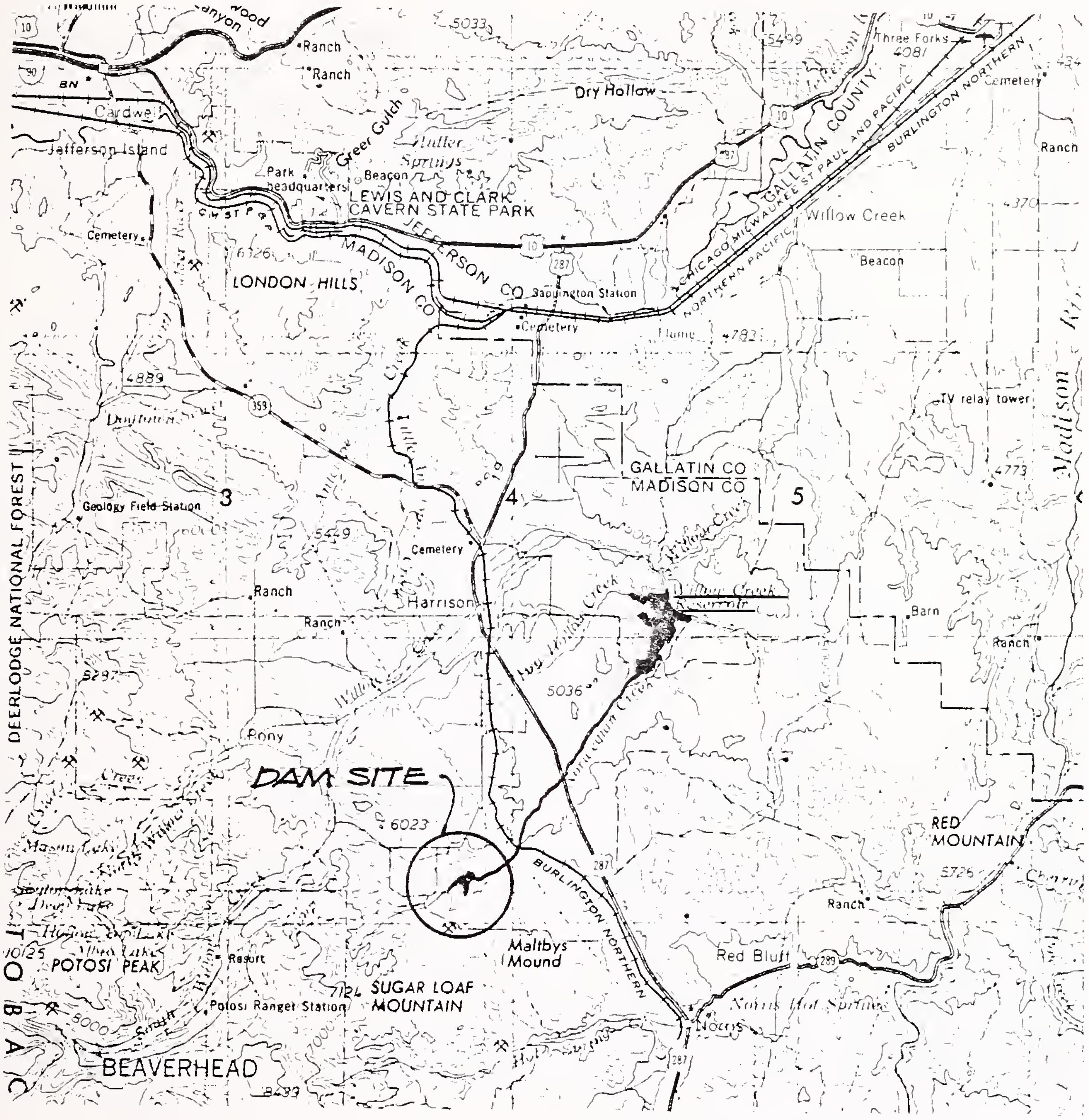
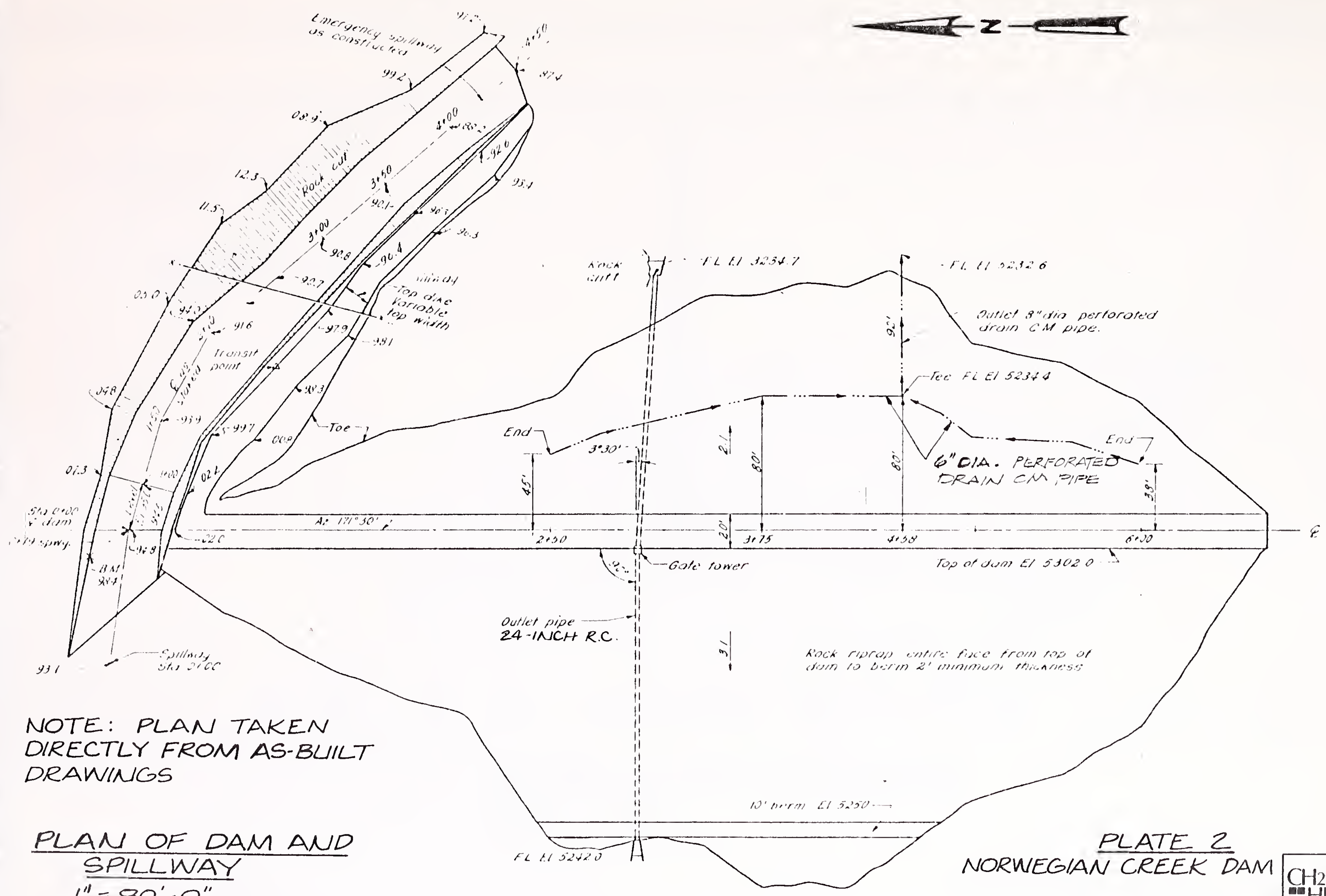


PLATE 1

NORWEGIAN CREEK DAM

VICINITY MAP

CH2M HILL

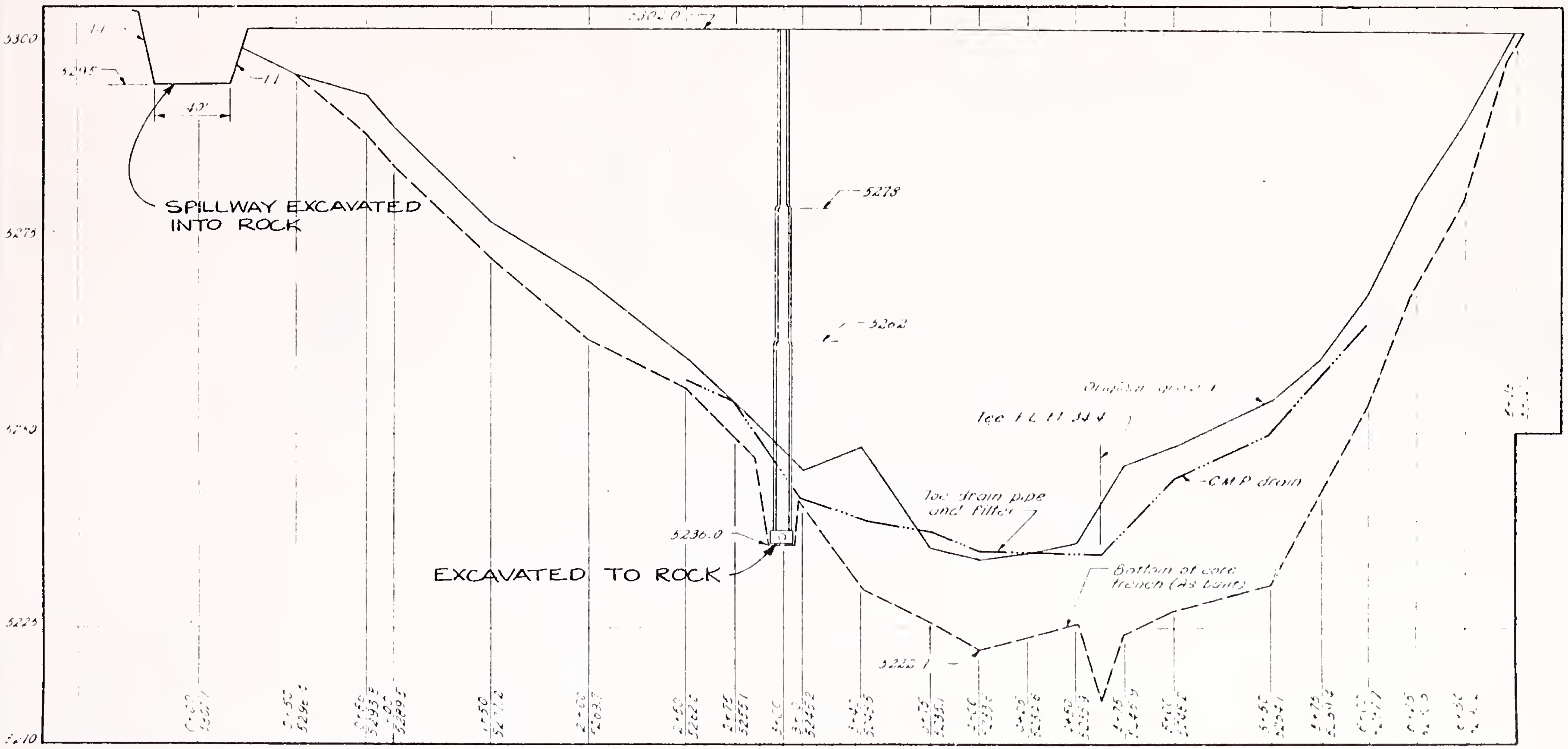


NOTE: PLAN TAKEN DIRECTLY FROM AS-BUILT DRAWINGS

PLAN OF DAM AND SPILLWAY
1" = 80'-0"

PLATE 2
NORWEGIAN CREEK DAM
SITE PLAN

CH2M HILL



SECTION OF DAM CENTERLINE

HORZ 1" = 80'
VERT 1" = 20'

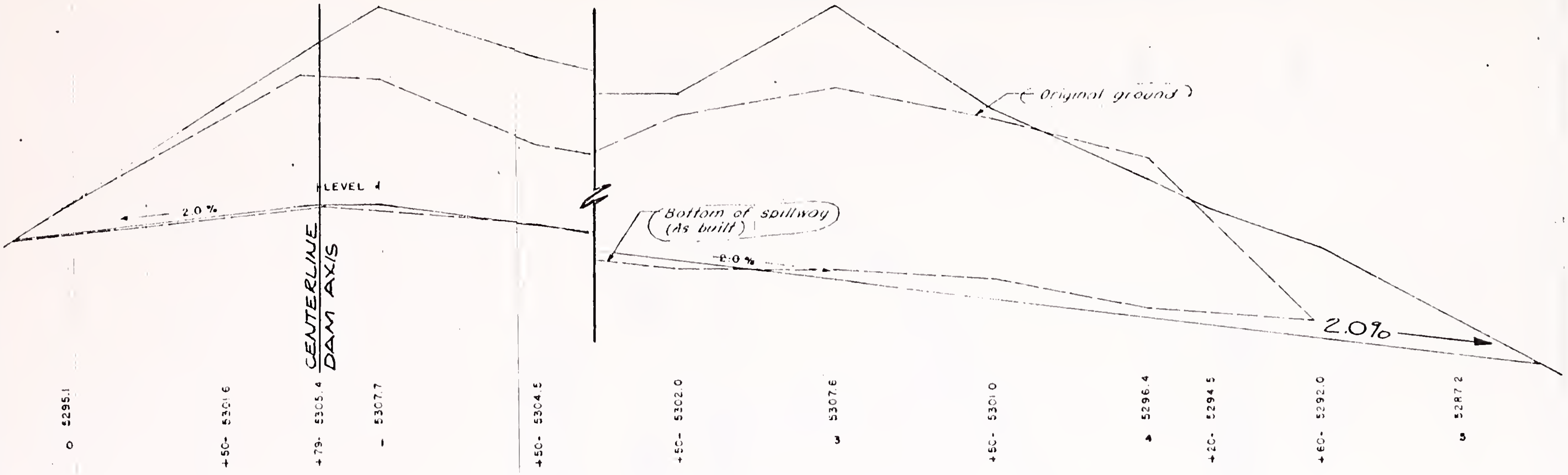
NOTE: SECTION
TAKEN DIRECTLY
FROM AS-BUILT
DRAWINGS

PLATE 3

NORWEGIAN CREEK DAM

SPILLWAY AND
EMBANKMENT SECTION

CH2M HILL



SPILLWAY PROFILE
HORZ 1" = 50'
VERT 1" = 10'

NOTE: PROFILE
TAKEN DIRECTLY
FROM AS-BUILT
DRAWINGS

PLATE 4
NORWEGIAN CREEK DAM
SPILLWAY PROFILE

CH2M HILL

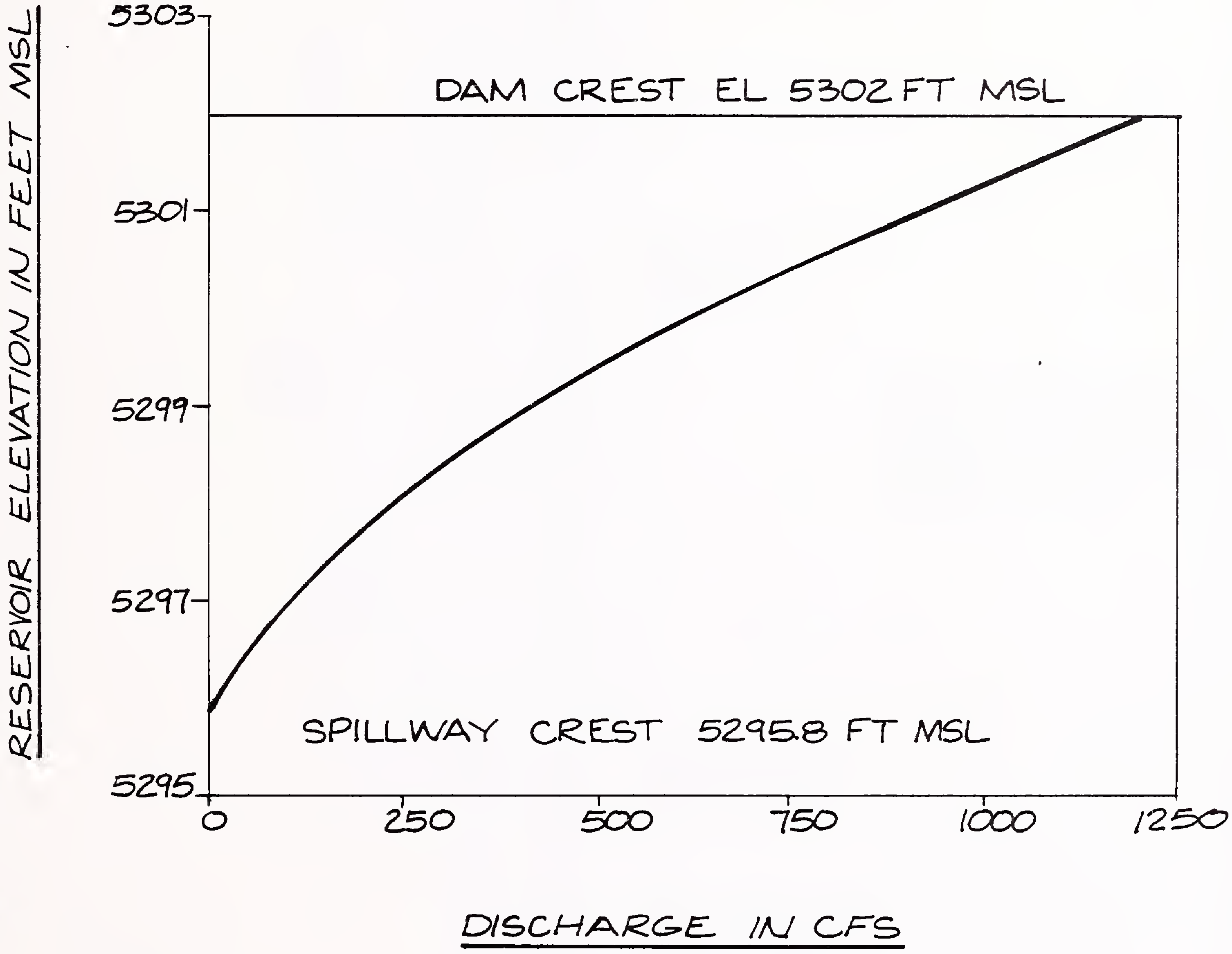
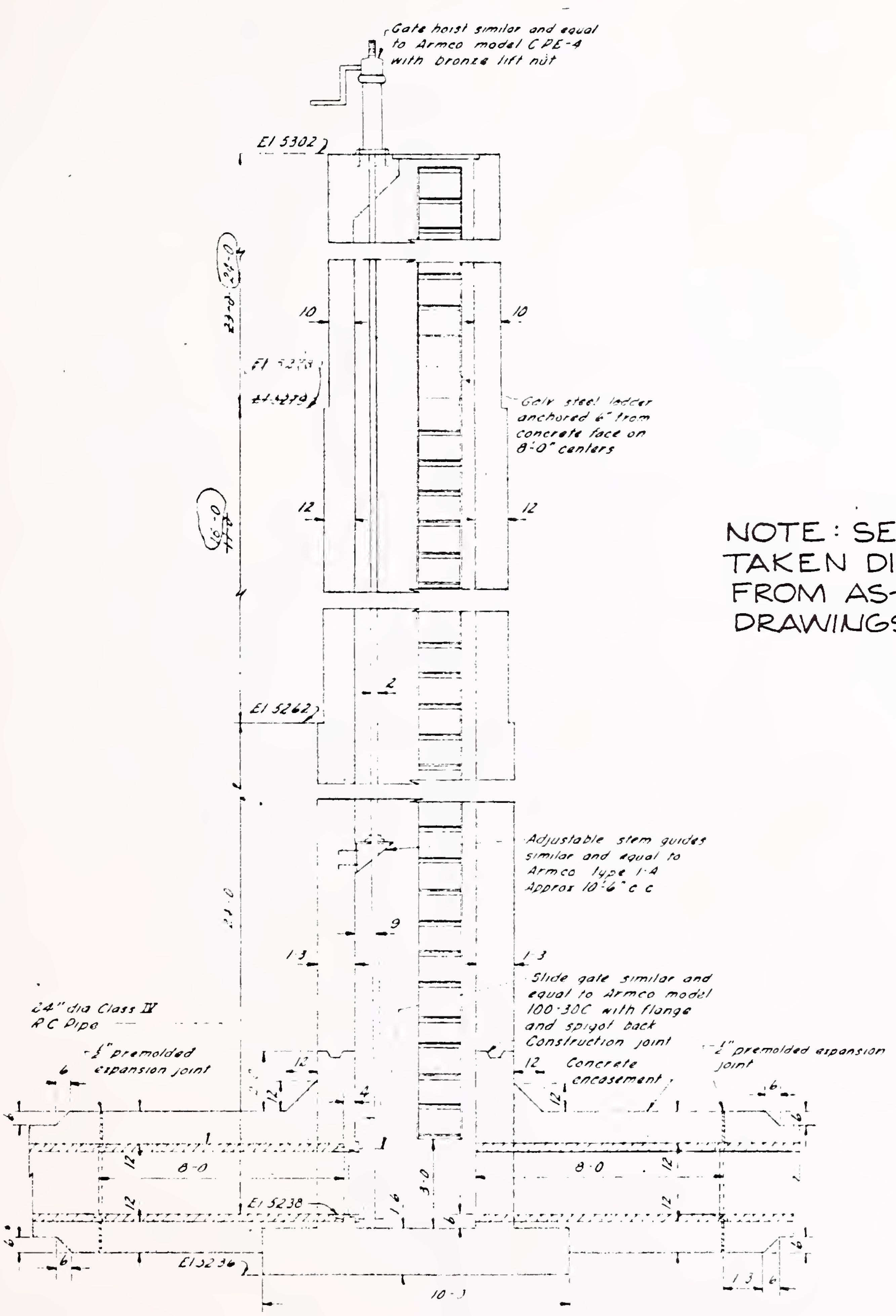


PLATE 5

NORWEGIAN CREEK DAM

SPILLWAY RATING CURVE

CH2M HILL


Gate hoist similar and equal to Armco model CPE-4 with bronze lift nut
El 5302
24'-0
23'-0
10
10
El 5279
Galv steel ladder anchored 6" from concrete face on 8'-0" centers
16'-0
14'-
12
12
2
El 5262
Adjustable stem guides similar and equal to Armco type 1-A Approx 10'-6" c c
21'-0
9
1-3
1-3
Slide gate similar and equal to Armco model 100-30C with flange and spigot back
Construction joint
24" dia Class IV RC Pipe
½" premolded expansion joint
½" premolded expansion joint
6
12
12
Concrete encasement
12
4
6
6
6
8-0
8-0
12
12
12
12
3-0
1-6
6
El 5238
El 5236
6
6
10-3
1-3
6

NOTE: SECTION TAKEN DIRECTLY FROM AS-BUILT DRAWINGS

GATE TOWER SECTION

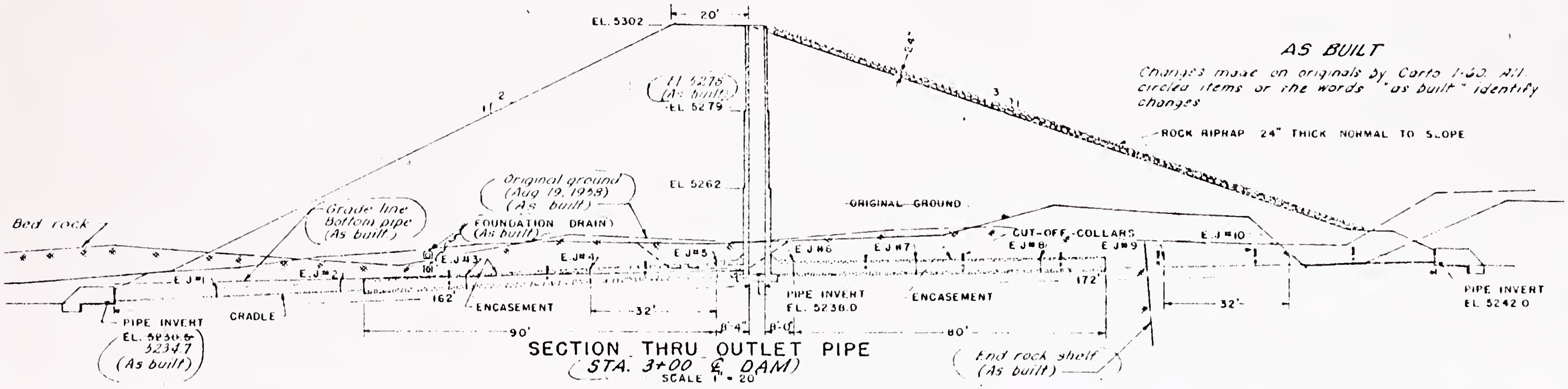
3/16" = 1'

PLATE 6

NORWEGIAN CREEK DAM

OUTLET WORKS
TOWER SECTION

CH2M HILL



DAM EMBANKMENT SECTION

1" = 40'

NOTE: SECTION
TAKEN DIRECTLY
FROM AS-BUILTS
DRAWINGS

PLATE 7
NORWEGIAN CREEK DAM

DAM EMBANKMENT
SECTION

CH2M HILL